Benchmark Field Testing and Evaluation of Commercial Desiccant Equipment

IES Peer Review Meeting - Nashville

May 1, 2002

Hugh I Henderson, Jr. P.E.

CDH Energy Corp.

Cazenovia, NY

www.cdhenergy.com

Overview

- Describe field test experiences with commercial desiccant systems
  - how well do conventional AC systems work?
  - can desiccant equipment efficiently improve IAQ?
- TRNSYS tool developed to address un-answered questions from field testing
- Implications for Desiccant Equipment
  - how should packaged equipment be configured for lowest cost / best efficiency

Field Test Sites

- **Elementary School in Olathe, Kansas**
- TJMaxx Store in Waltham, Massachussetts

Other Recent Field Test Sites

- Tampa Vocational School (AIL Research)
- Nursing Home in Wilmington, Deleware (Energystics)

Elementary School
Olathe, Kansas (Kansas City)

- Elementary school built in 1988. New addition in 1995
- Water Loop Heat Pump (WLHP) System
- Good "side-by-side" test site in moderate climate

Two Identical "Pods"

Base Case Pod

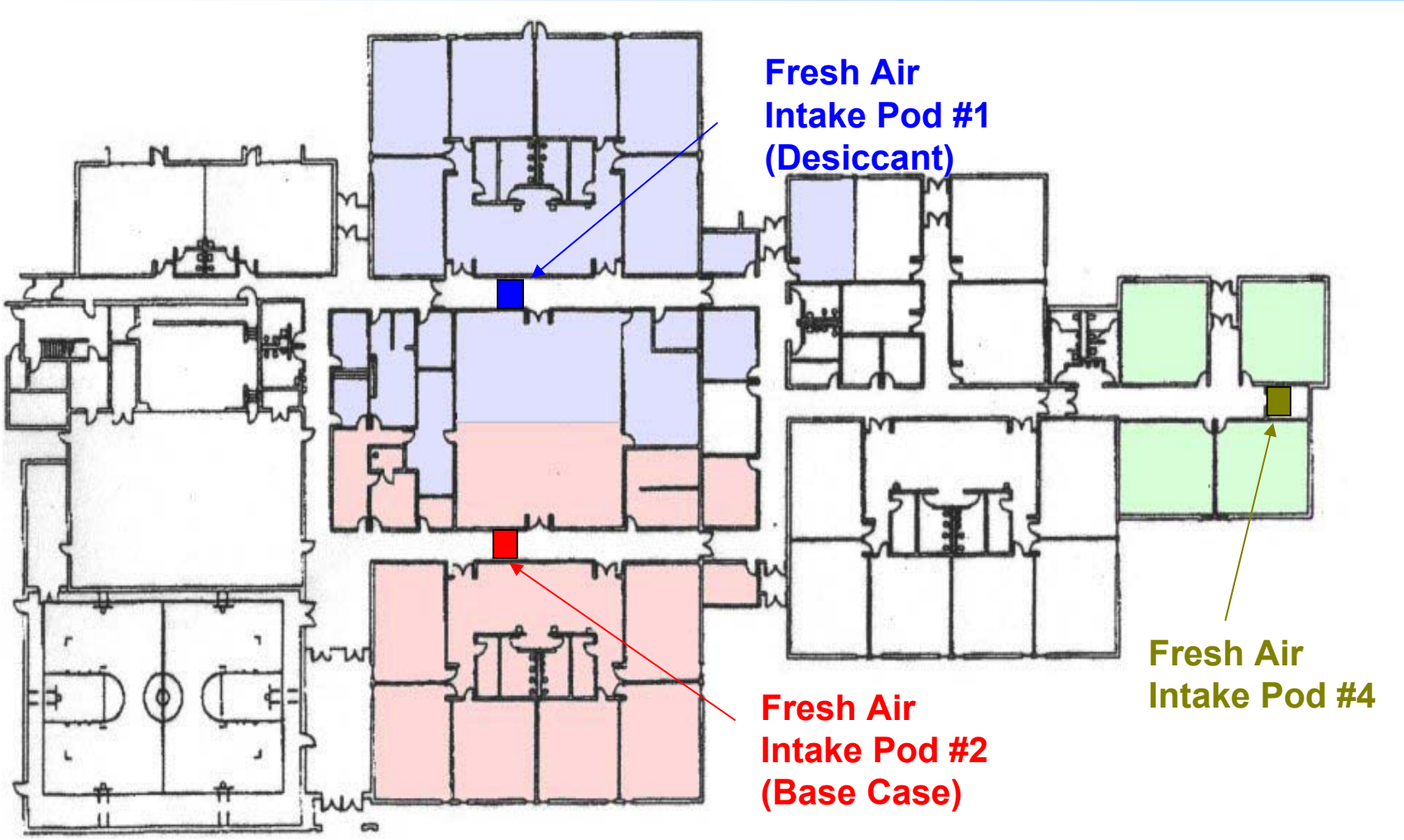
- separate fresh air intakes (ducted to WLHPs)
- 120 students nominal

- <u>Both Pods Have</u>:
- 6 classrooms & wet area
- same no. & type of WLHPS

Desiccant Pod

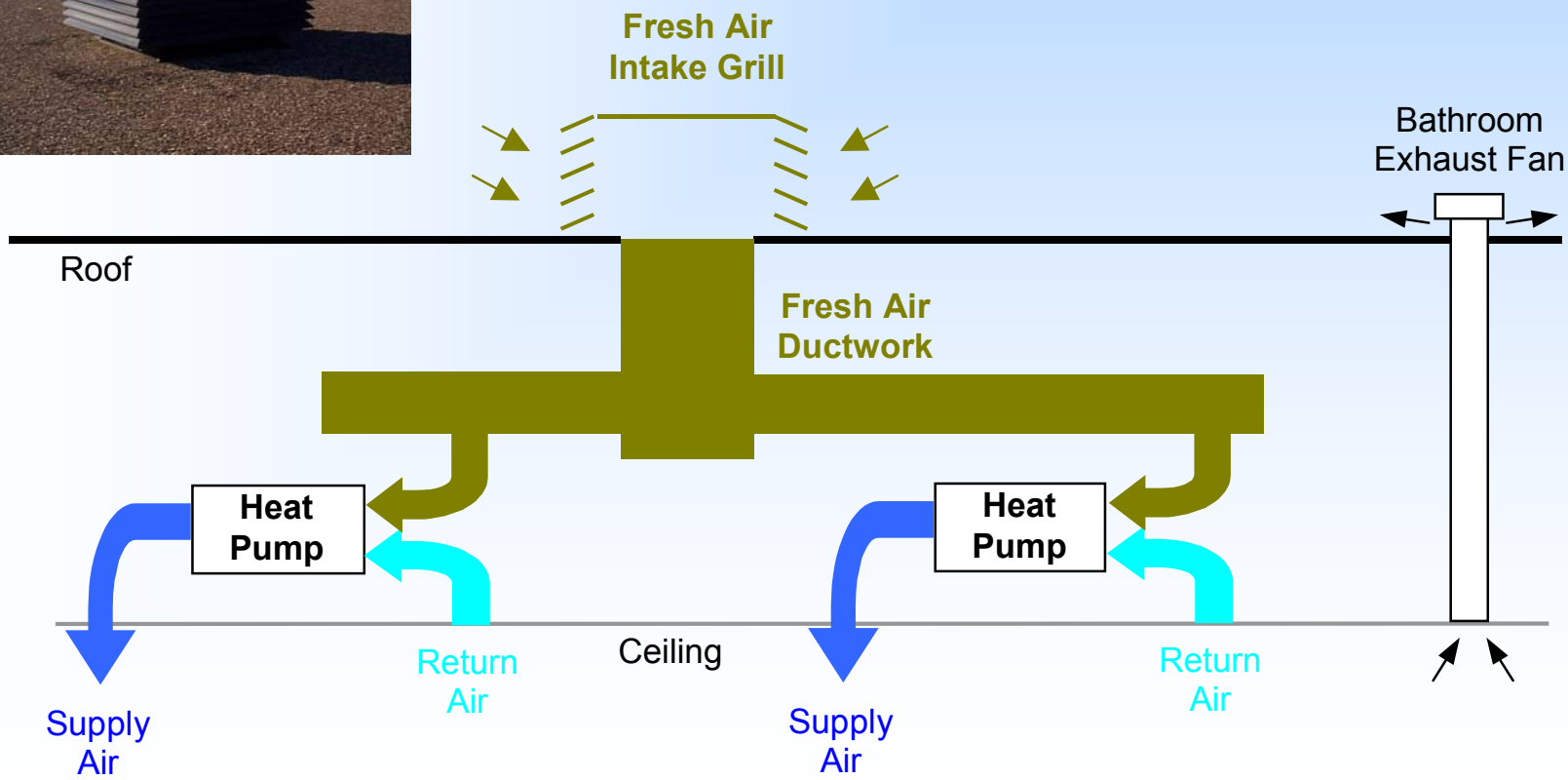
School Layout

Fresh air intakes also serve other areas!



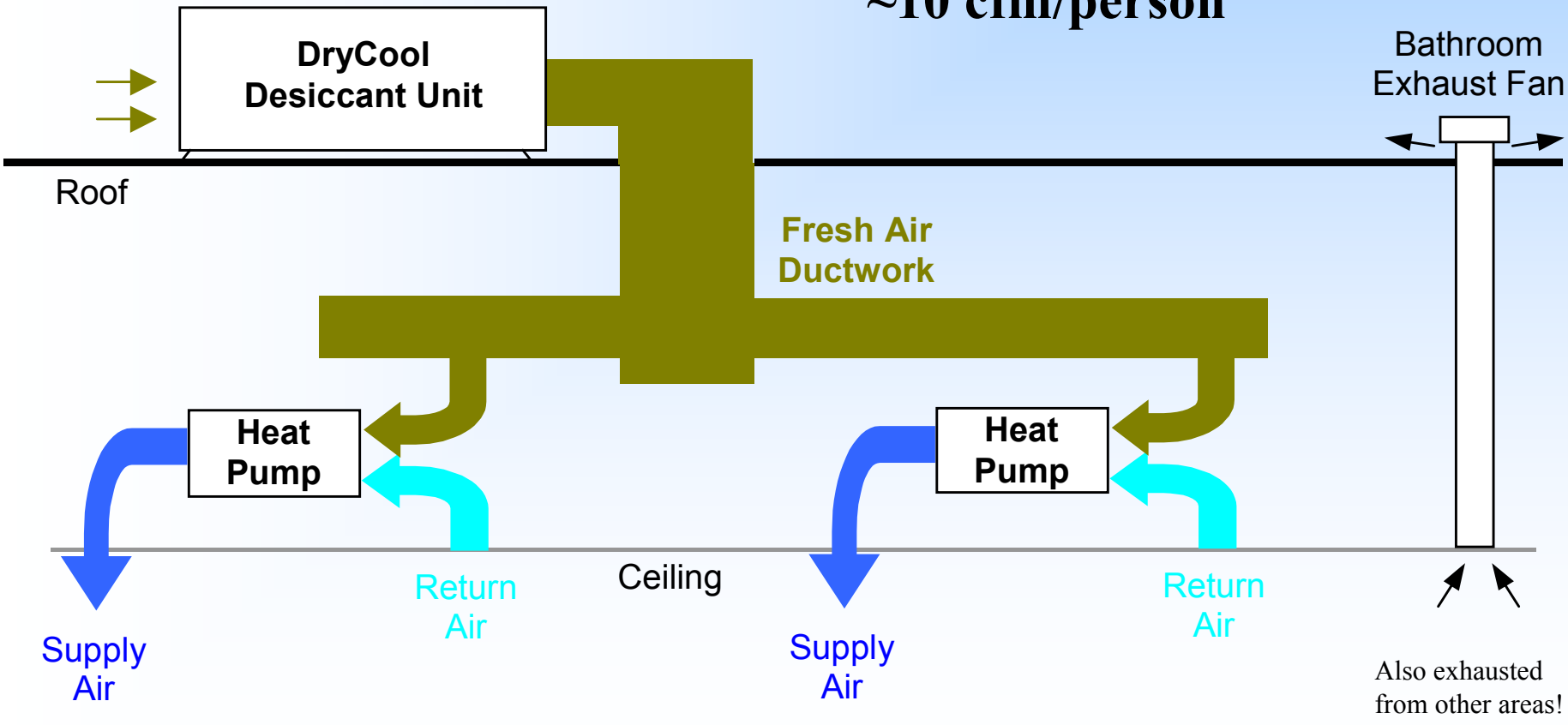
Pod #2 - Current Fresh Air System

Ventilation:
~4 cfm/person

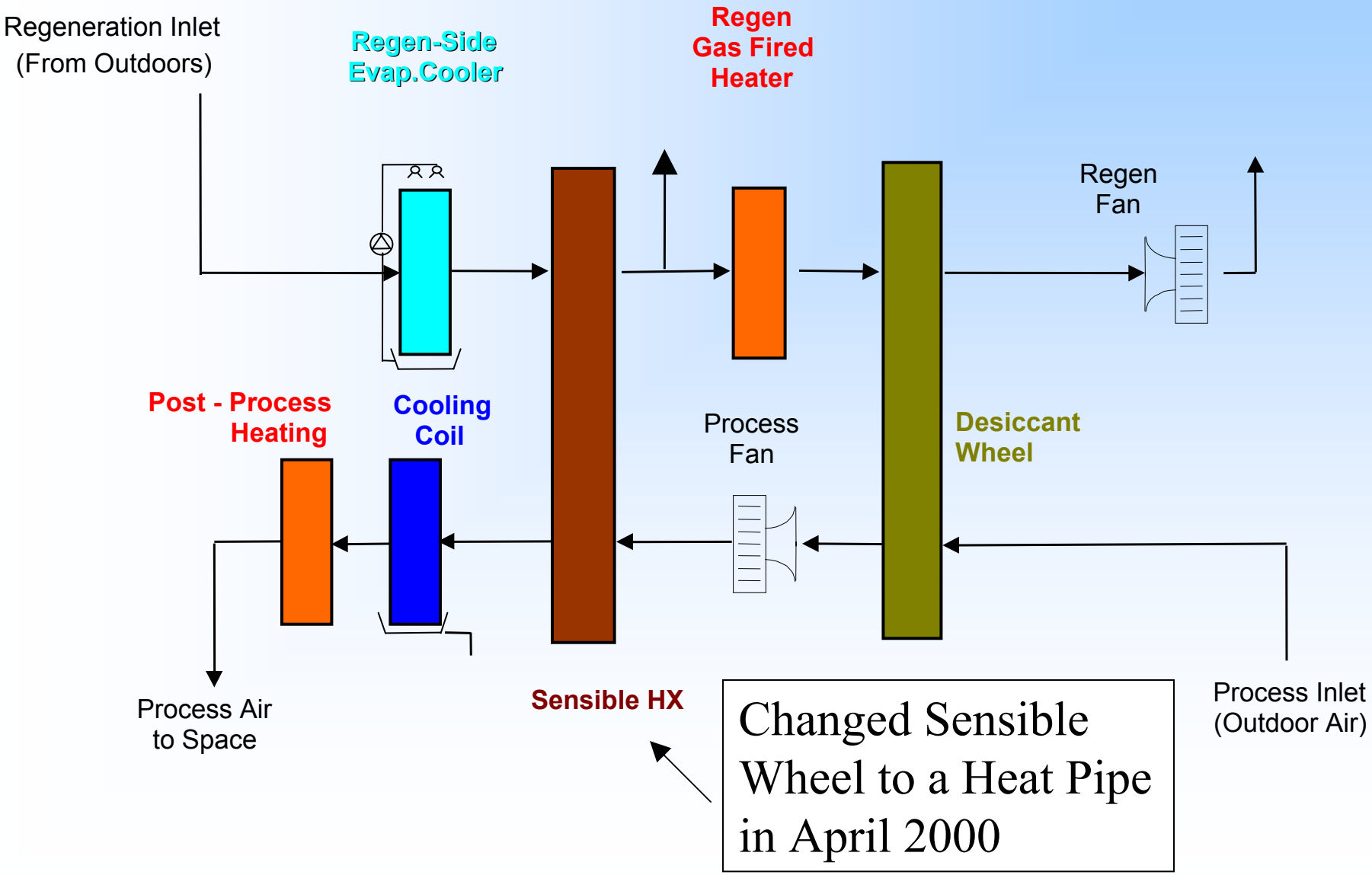


Pod #1 - New Desiccant System

Ventilation:
~10 cfm/person



Desiccant Unit Configuration



Changed Sensible Wheel to a Heat Pipe in April 2000

Field Test Approach

- Monitor all three pods *and* fresh air systems
- Collect detailed data (Feb 1999 to Aug 2000)
  - fully monitor status, energy use, and performance of heat pumps in each Pod (sensible cooling system)
  - measure space T, RH, & CO_2 in each Pod
  - quantify *actual portion* of fresh air into each Pod with T&B readings & CO_2 concentrations
  - quantify desiccant unit and fresh air HP performance, status, and energy use

Data Acquisition System

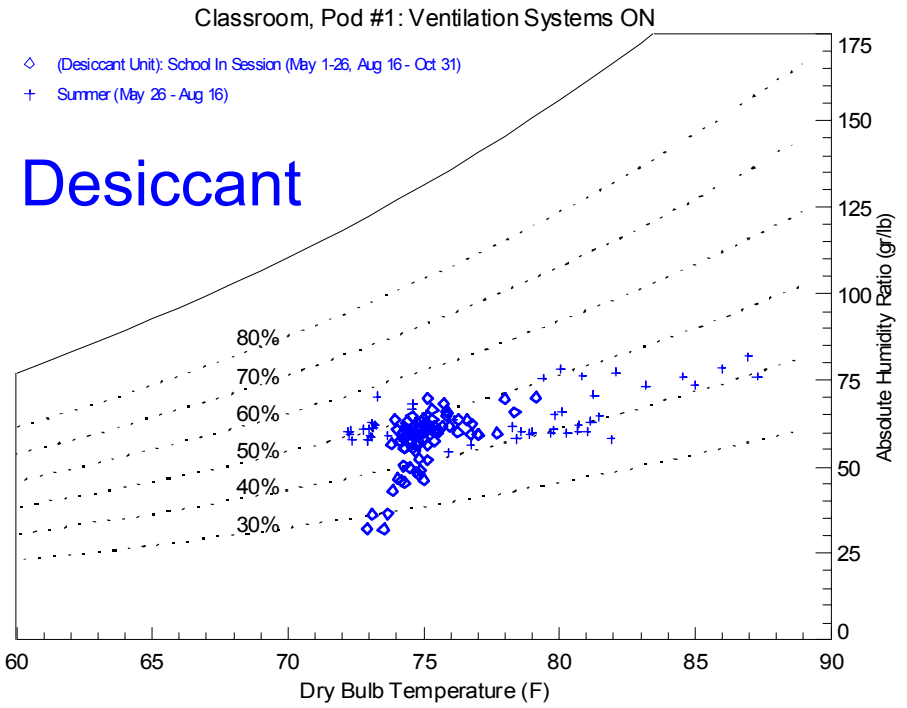
- Data Logger for Desiccant Unit (**A**)
- Data Logger for Pod Areas & Heat Pumps (**B**)
- Data Logger for Fresh Air HP & Pod #4 (**C**)
- Total of 106 data points logged every 5 minutes

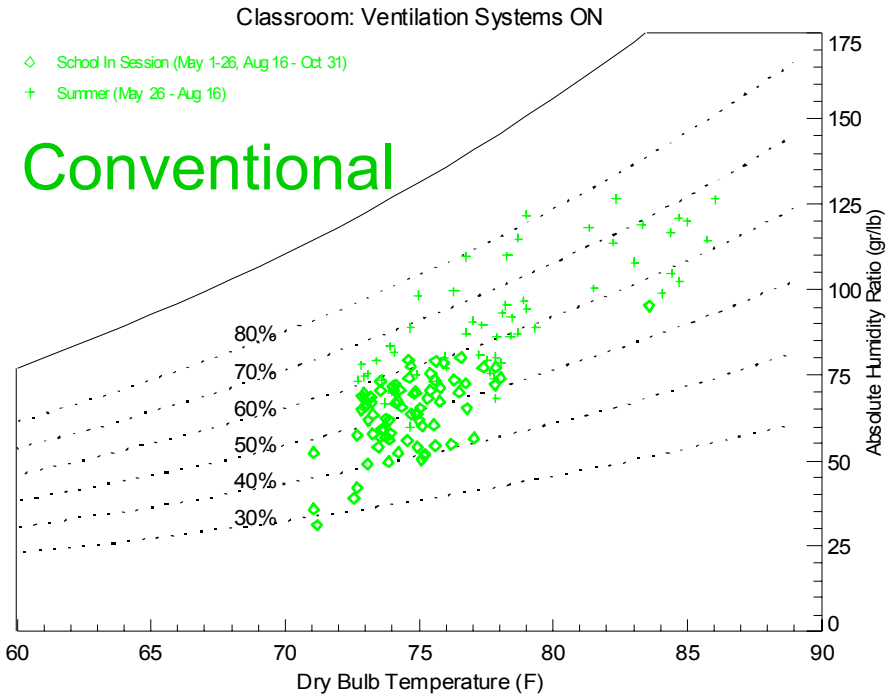
Data Logger B - Pod Areas

Initial Operating Issues

- Sensible heat wheel was found to be 35% effective “moisture exchanger” during 1999 season
  - tests of similar wheel at NREL confirmed oxidation changed sensible HX into “enthalpy wheel”
- Heat pipe HX installed in April 2000
  - approx 73% effective (slightly unbalanced)
- Desiccant system operated as expected with heat pipe installed

Desiccants Clearly Provide Better Humidity Control

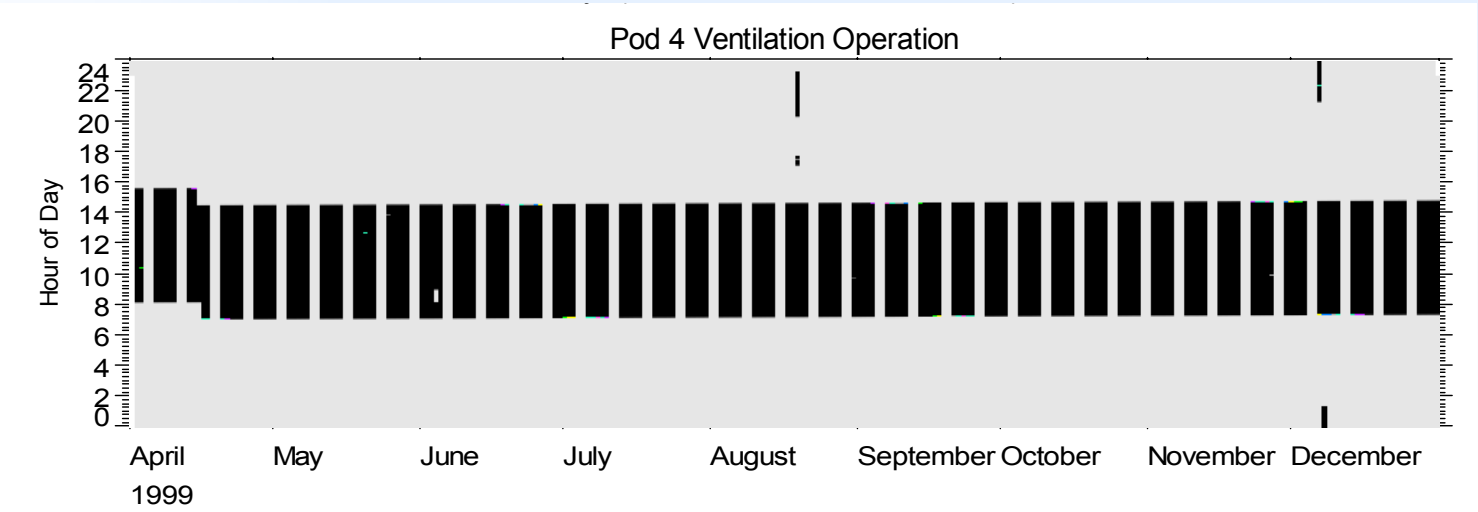




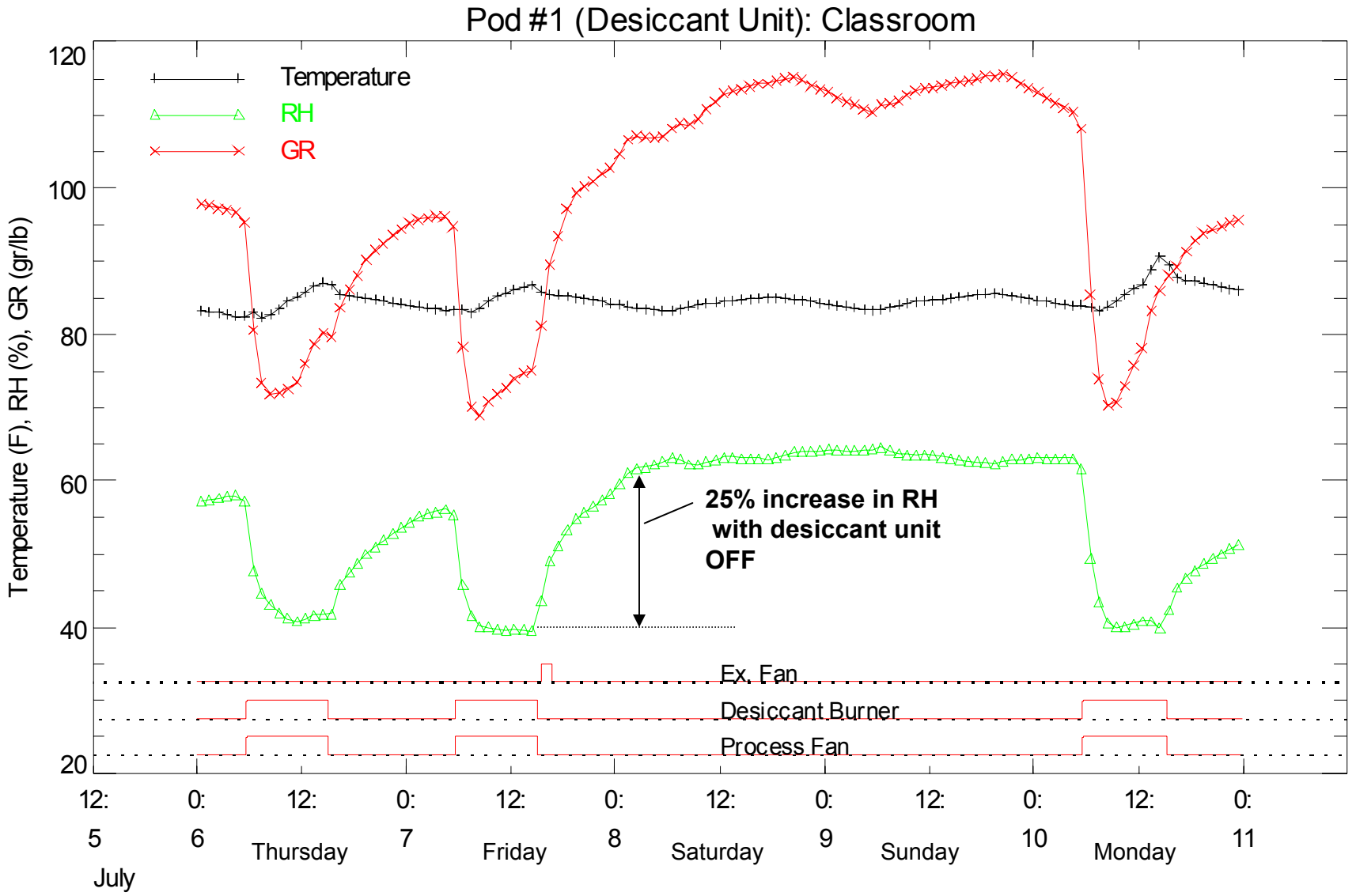
Maintained lower and more consistent humidity levels

School Operating Patterns

- Space conditioning & ventilation provided from 7 am to 3 pm weekdays
  - most systems shut down in Summer from May 15 to August 15
- What happened to space conditions during unoccupied periods?



What Happens on Weekends?

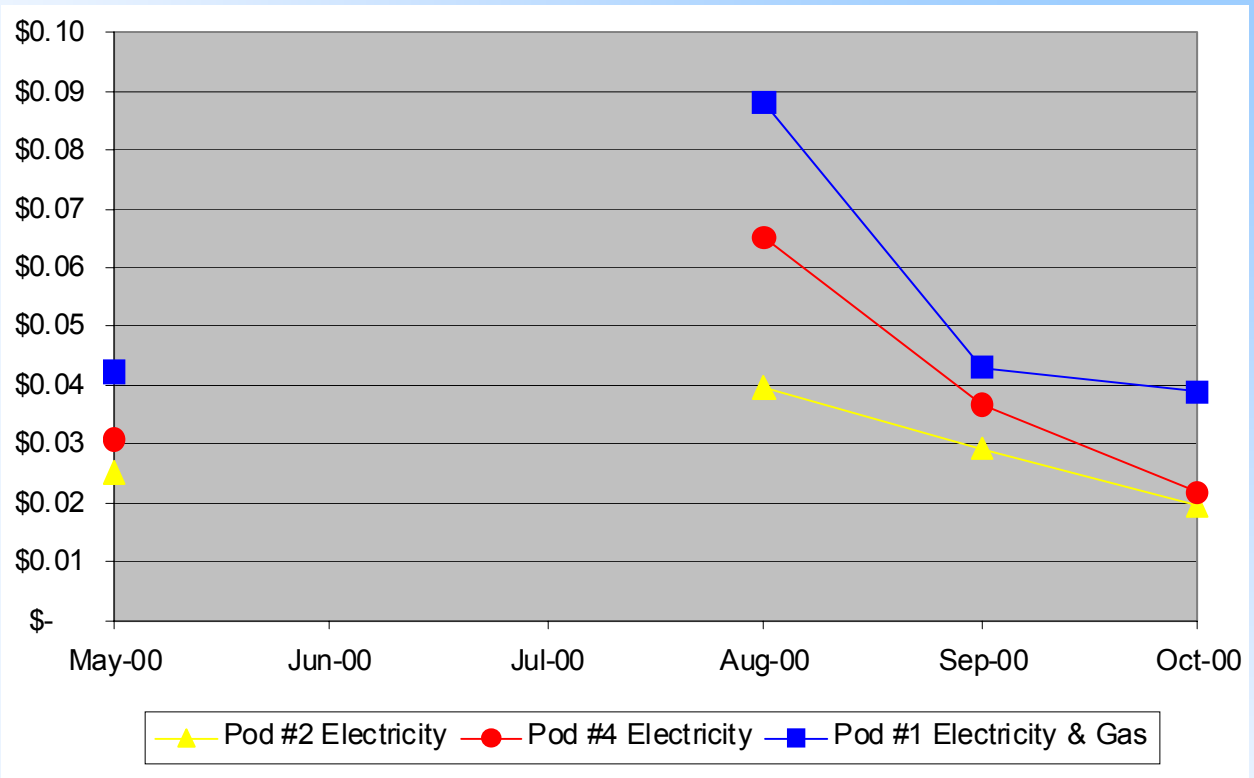


Energy Use Breakdown

	POD #1 Desiccant – 10 cfm/p				POD#2 4 cfm/p	POD #4 Conventional – 15 cfm/p			
Month	**Des Unit (therms)**	**Des Unit (kWh)**	**WLHPs (kWh)**	**Total (kWh)**	**WLHPs (kWh)**	**FAHP (kWh)**	**Duct Heater (kWh)**	**WLHPs (kWh)**	**Total (kWh)**
Nov-99	323	810	1,250	2,060	1,068	167	167	268	602
Dec-99	371	847	738	1,585	545	175	909	360	1,445
Jan-00	352	755	724	1,479	477	162	1,207	507	1,875
Feb-00	208	708	489	1,197	512	160	581	341	1,082
Mar-00	208	796	266	1,062	664	161	308	276	746
Apr-00	-	806	434	1,240	935	209	133	466	808
May-00	90	1,119	1,182	2,301	1,841	164	-	744	908
Jun-00	152	1,355	782	2,137	597	162	-	155	317
Jul-00	239	1,886	1,044	2,931	808	175	-	239	413
Aug-00	227	2,008	2,448	4,457	2,899	210	-	1,703	1,913
Sep-00	65	1,022	1,550	2,572	2,144	168	0	908	1,077
Oct-00	102	966	983	1,948	1,435	158	19	463	640
Annual	**2,337**	**13,078**	**11,890**	**24,968**	**13,923**	**2,070**	**3,324**	**6,430**	**11,824**
		(52%)	*(48%)*	*(100%)*	*(100%)*	*(18%)*	*(28%)*	*(54%)*	*(100%)*

Notes: Desiccant unit gas use includes dehumidification and vent pre-heating. Desiccant unit electric use includes ventilation/process fan, regeneration fan, and AC condensing unit for post-cooling coil. WLHPs – water loop heat pumps in each Pod. FAHP is fresh air heat pump in Pod #4.

Comparing HVAC Operating Costs



Energy Use Summary for the Three Pod Areas (May, August, September & October 2000)

System	Electric Costs ($/sq. ft.)	Gas Costs ($/sq. ft.)	Total Costs ($/sq. ft.)	Increased Energy Costs
Pod #2 Base-case - 4 cfm	0.11	-	0.11	-
Pod #4 Fresh air HP - 15 cfm	0.15	-	0.15	+36%
Pod #1 Desiccant - 10 cfm	0.15	0.06	0.21	+86%

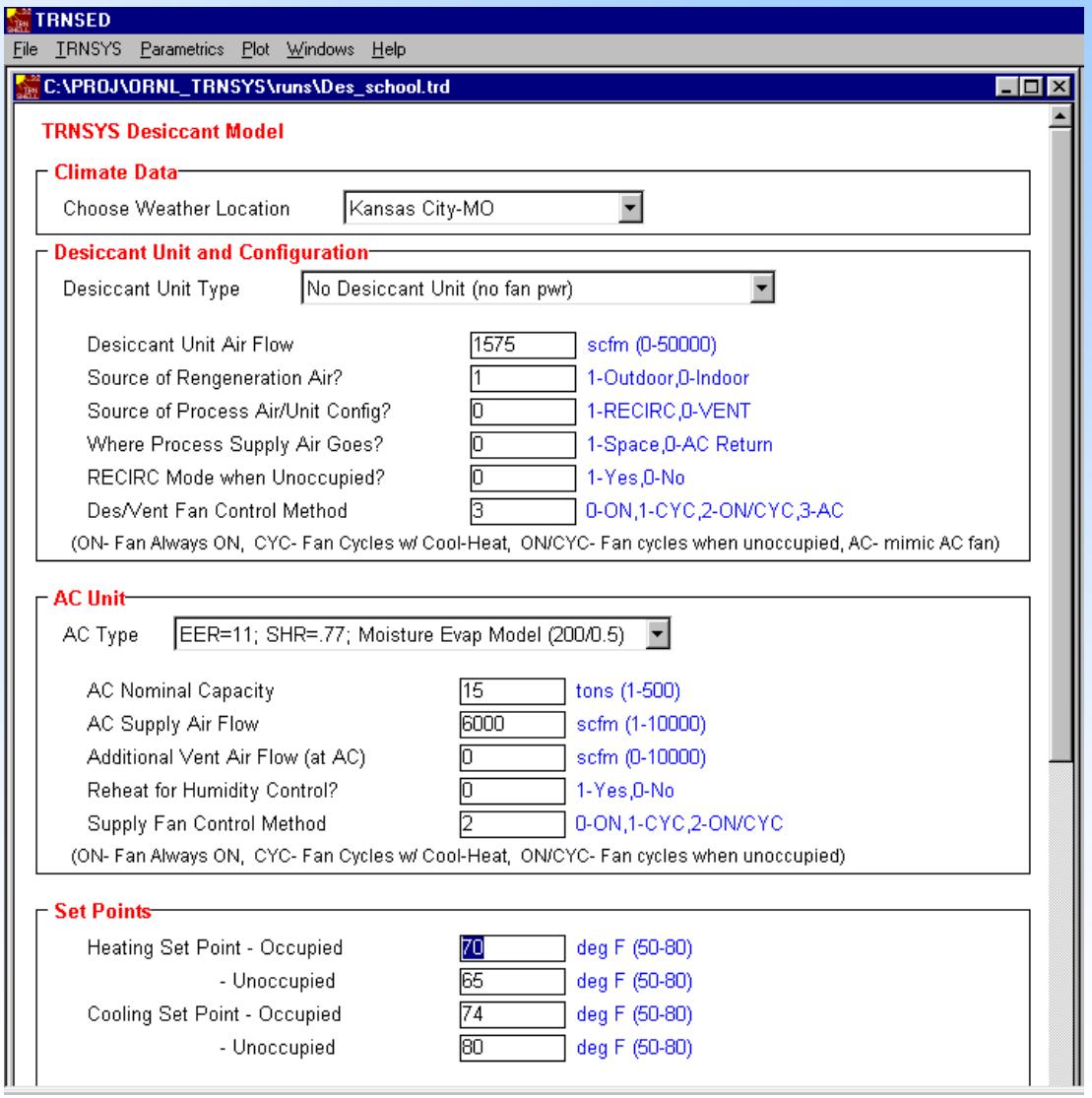
Notes: $0.08/kWh and $0.70/therms

Why are Desiccant Operating Costs Higher?

- Meeting additional load
  - more moisture removal
- Desiccant unit fan power is 2-3 times a conventional rooftop unit (~1-2 Watts/cfm)
  - ventilation must be supplied through des wheel for entire year
- Are components such as sensible heat wheel and evaporative cooler cost effective?
  - do energy benefits justify added equipment costs

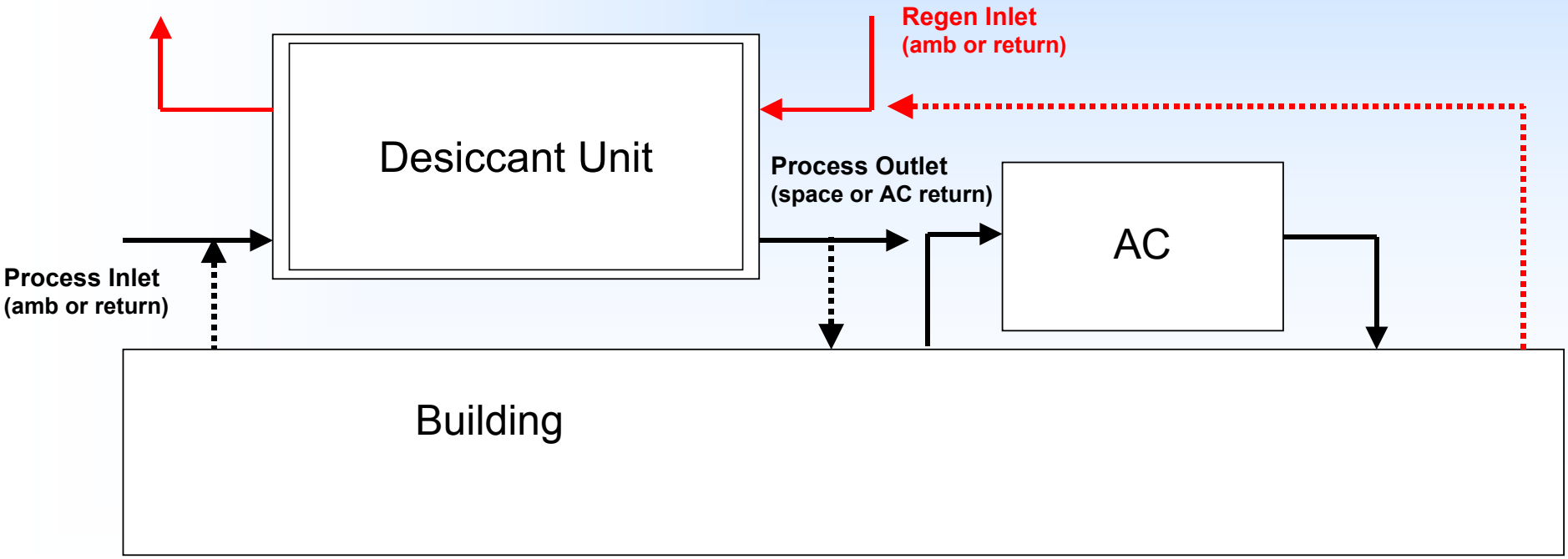
TRNSYS Model of Desiccant Systems

- One-zone hourly building model
- Compare various component configurations
- Consider different control options
- Partload impacts!

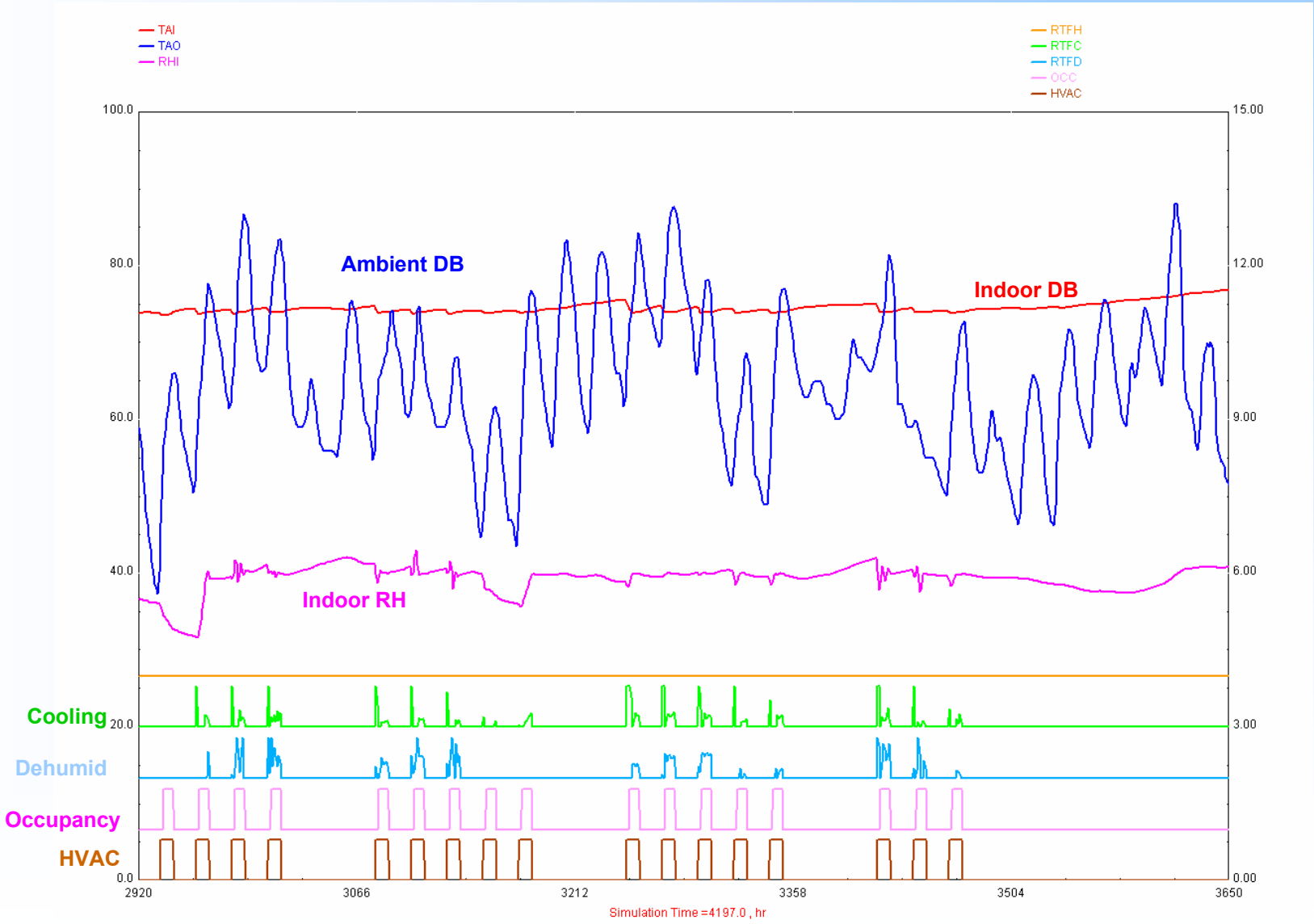


Tool Configuration Options

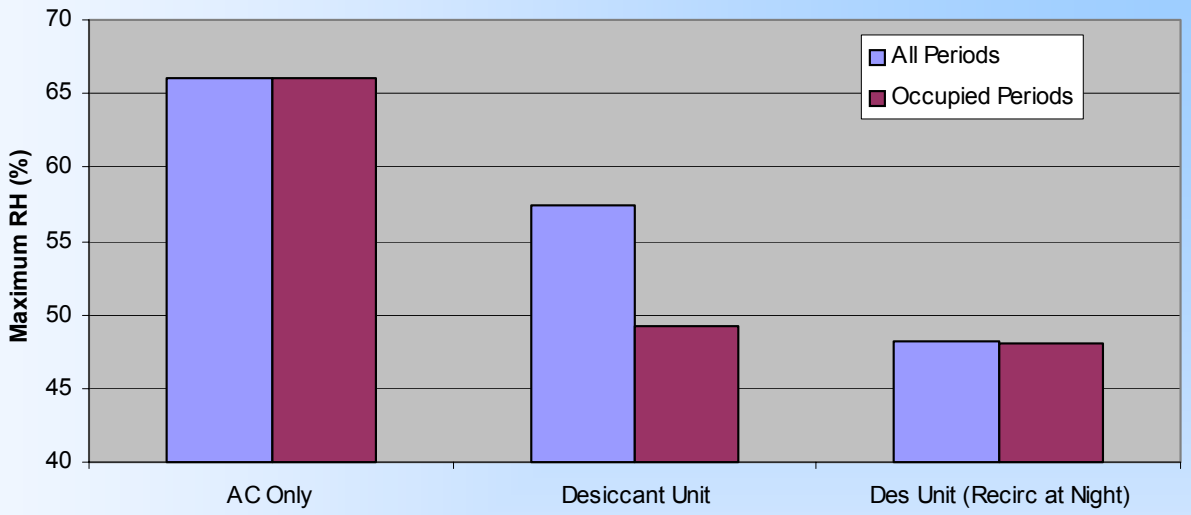
- Configuration affects energy use & space conditions
- Control options (fans, set pts, etc)
- Considers part load and annual impacts

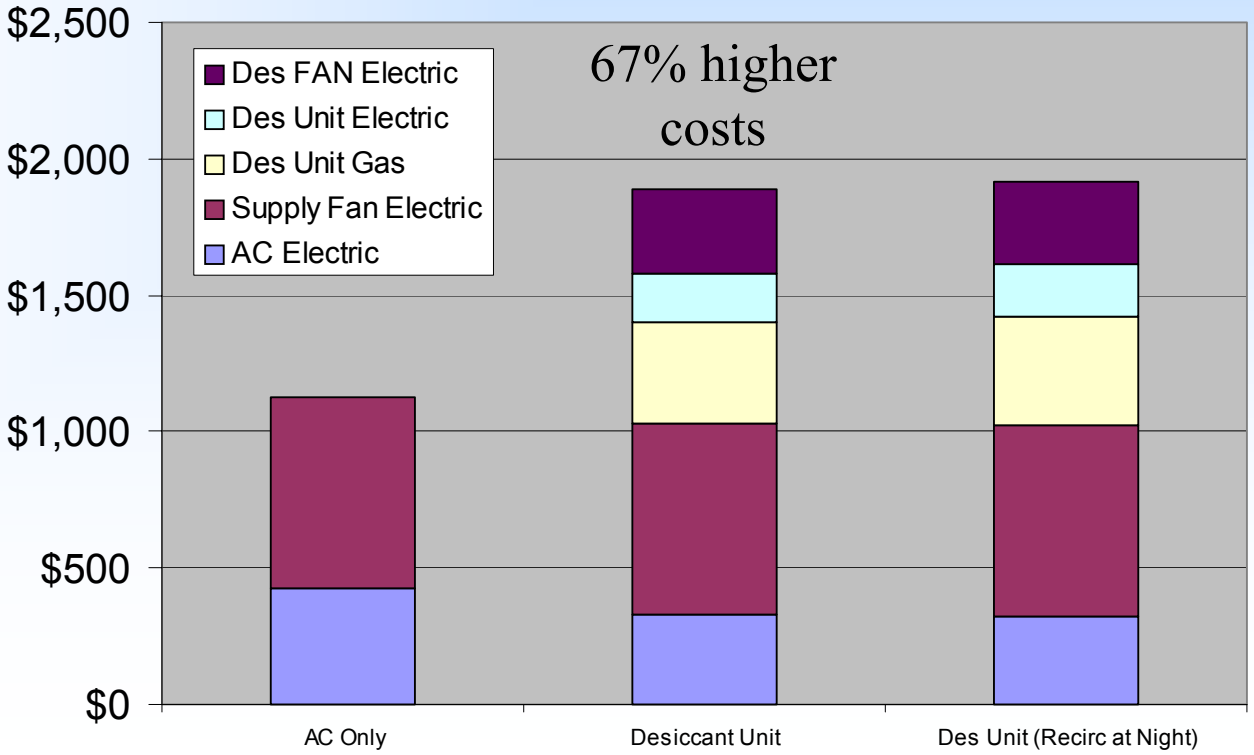


Hourly Simulation Snapshot

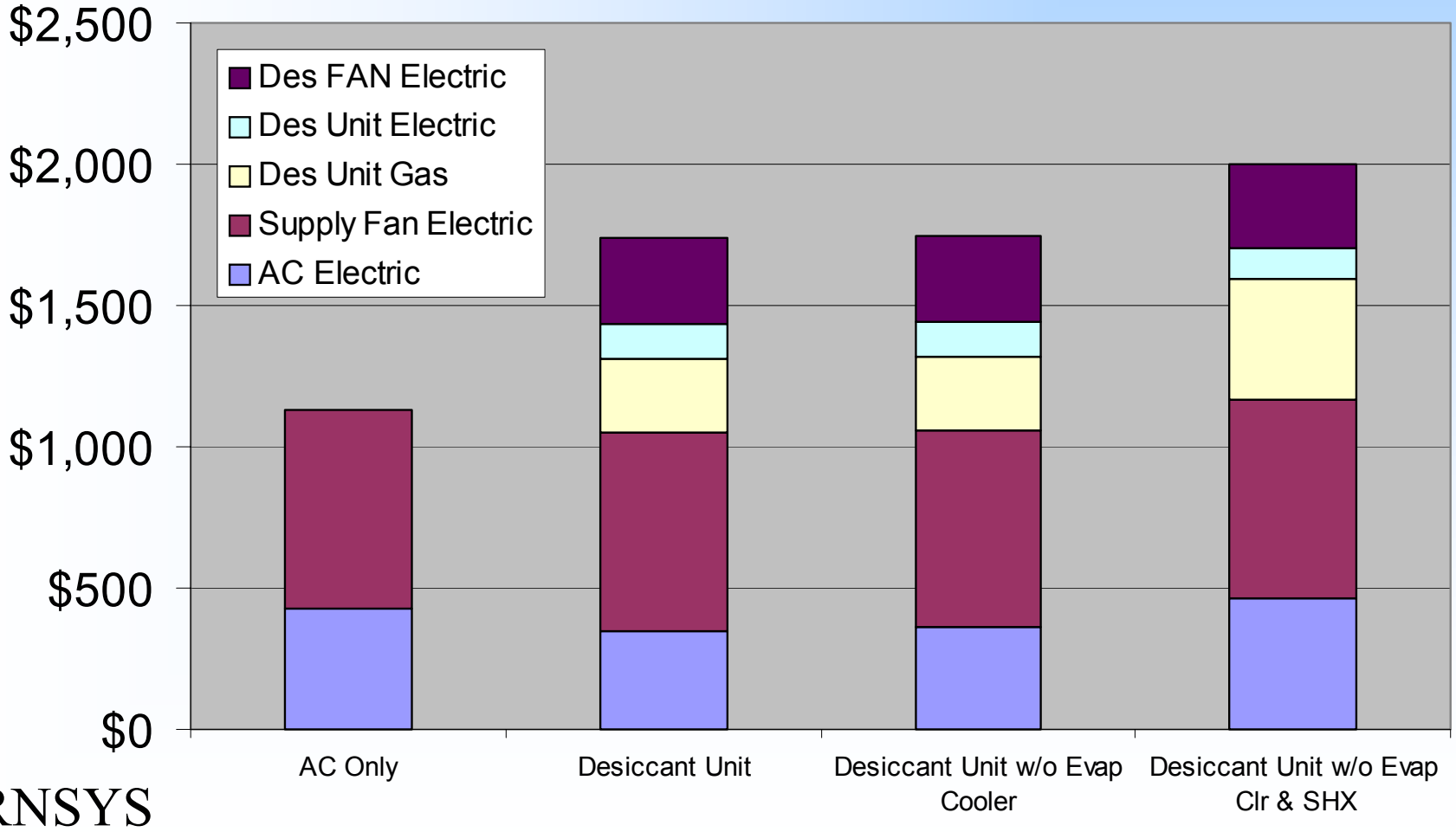


Predictions with TRNSYS





Impact of Sensible HX & Evap Cooler

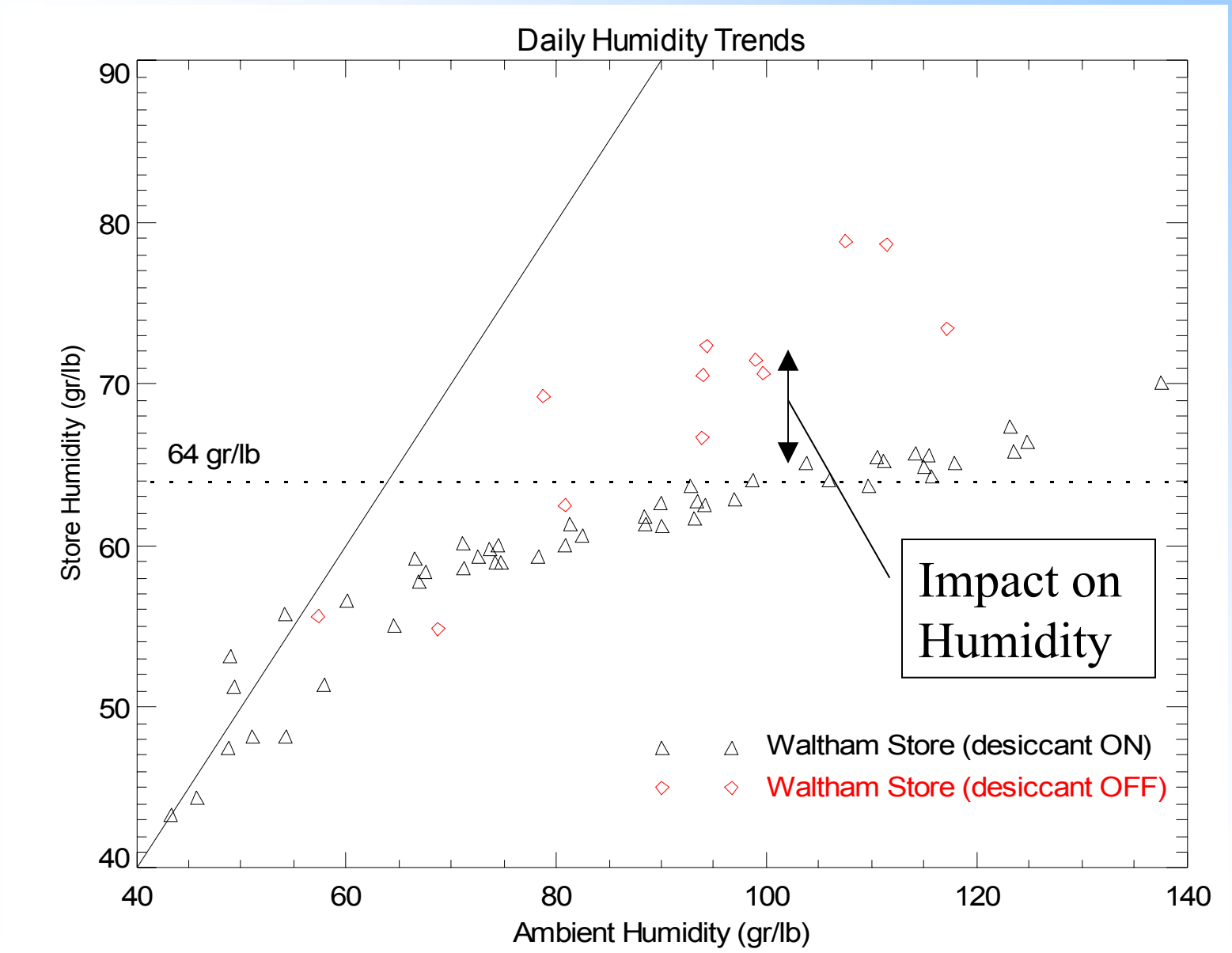


TRNSYS

TJMaxx Store

- 26,000 sq ft store in Waltham, MA
- Packaged Munters Unit provides cooling, ventilation, and dehumidification
- Desiccant unit w/o SHX
- Replaced old 25 ton rooftop on one side of store
- Side-by-side comparison with similar store

TJMaxx Humidity Improvement



Summary

- Desiccant systems can provide better humidity control
  - more consistent than conventional AC
- Equipment configuration greatly affects energy use
- Must consider part load/annual implications of components
  - Ex: evap. cooler good at peak load, but little benefit on annual basis

Summary (cont.)

- Other desiccant system configurations may have lower operating costs
  - especially configurations that let conventional AC meet part of latent load
  - don't treat the entire ventilation or supply air stream (allows for smaller equipment)
- Added fan power is often more than gas use
  - we can't expect better fans
  - but smarter configurations are possible